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MFS
MONARO FARMING SYSTEMS

Exploring lamb finishing systems on the Monaro

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Introduction

On the Monaro sheep production systems have been traditionally based on self-replacing merino enterprises predominantly for fine wool production. Recent years have seen a shift in the relativities between wool and lamb prices and increasing opportunistic joining of merino ewes to maternal or terminal sires to take advantage of soaring sheep meat prices. Often in systems more geared toward merino production these lambs are sold at lighter weights rather than retained and finished to heavier weight specifications.

A run of good seasons and greater financial security has generated more interest in expanding the lamb enterprise on many farms and with this an interest in systems that might more reliably finish lambs to heavier weights. Of particular interest is the use of more specialized finishing pastures and crops with reliable production of high quality forage during summer and early autumn when native pastures and even temperate improved pastures deteriorate in quality and lamb growth rates decline.

Monaro Farming Systems identified a knowledge gap regarding the relative economic value of finishing lambs compared to selling as stores given the likely trade-off between the total number of ewes joined (and hence lambs produced) and the final weight of those lambs. If lambs are retained for longer to finish at higher weights this is likely to be at the cost of ewe numbers but the extent of the trade-off needed to be quantified. As the question is one of whole farm management it is a difficult question to research in the field so a decision was made to first explore the question by farm systems modelling using the GrassGro decision support tool.

GrassGro has already been well characterised and validated for the Monaro region and is already regularly used in other MFS projects. It made sense in this case to build on the farm systems already characterised and use the Native grass and Phalaris based pasture systems on the basalt soil at Bungarby to create a farm system that was a mix of fertilised and unfertilised native pasture along with Phalaris based improved pastures. An enterprise that joined Merino ewes to terminal sires was simulated and stocking rates optimised for selling lambs as stores compared with retaining and selling as late as the end of April.

Overlaid on these base systems was the option of sowing Lucerne or a summer forage brassica as specialist finishing pastures. Lucerne has been parameterised for the GrassGro DS tool so this option was explored directly within the model however forage brassica is not parameterised for GrassGro so its feed value to the enterprise was determined outside of the model and then included within GrassGro as a production supplement fed only to weaned lambs in a feedlot and the total area available for ewe grazing reduced by the area cropped.

Method

Common inputs

The GrassGro decision support tool was used to compare various lamb finishing systems with the baseline practice of selling crossbred lambs as stores. All simulations are historical running from 1960 – 2015 inclusive using weather data from the SILO data drill (36°39'S,149°00'E). The enterprise tested is a breeding flock of Merino ewes joined to Poll Dorset sires weighing 90kg in condition score (CS) 3 to start lambing on the 1st of August. Replacement hogget ewes are purchased each February after 6 $^{1}/_{2}$ year old ewes are cast for age in January. The genotype is the average genotype determined from an earlier analysis of the first MFS wether trial having a reference weight of 45kg average greasy fleece weight of 5.6kg and a fibre diameter of 18.6 microns. Conception rates at CS3 are set to 55% singles and 40% twins with 5%. Livestock feeding is confined to maintenance feeding based on condition score thresholds so lamb growth is restricted to that which can be achieved from grazing pastures, Lucerne and brassicas.

The model farm is 1000ha entirely on basalt soils located at Bungarby. There are three basic pasture types comprising of 250ha (5 x 50ha paddocks) of improved phalaris pasture with sub-clover and annual grasses (PHL), 350ha (5x70ha paddocks) of fertilised native pasture dominated by Poa spp and Austrostipa spp with annual legumes (H-NAT) as well as 400ha (4x100ha paddocks) of unfertilised native pasture with the same species mix (L-NAT). Fertilised and unfertilised paddocks use soil fertility scalars of 0.85 and 0.75 respectively. Sustainable stocking rates were defined as the maximum possible while maintaining average ground cover of pasture above a minimum of 70% for 7 years out of 10.

More details on the initial parameters of soil, pastures and animals can be seen in Appendix 1.

Grazing Management

The inclusion of many paddocks in the systems brings the requirement for a grazing management plan to ensure that paddocks are utilised in accordance with their carrying capacity. To this end GrassGro allows for two types of grazing rotation which can be altered sequentially throughout the year.

1) Pastures can be grazed on a time based rotation with animals visiting paddocks for a defined number of days in a fixed order.
2) Pastures grazed on a flexible rotation where animal movement and paddock choice is determined by the goal of maximising livestock performance. Stock movement rules are based firstly on a minimum time spent in any one paddock and then movement to the best available paddock according to where their weight gain can be maximised.\

Lamb Selling Strategies

Young stock sales in GrassGro can be managed in three ways.

1) Stock can be sold on a fixed date
2) Stock can be sold at a target weight any time before a fixed final date for sale.
3) Stock can be sold at a target weight any time between fixed start and final dates but sale may also be triggered if a target weight gain is not met. This option allows animals to be sold earlier in poor seasons before they slip too much but also allows them to be retained to the heaviest desirable weight in good seasons.

In the baseline scenario lambs are sold on the 31st of December regardless of their live weight or the remaining pasture available. For the pasture and Lucerne based finishing systems lambs are retained until at least 1st of February after which time lambs are sold if pasture conditions have not consistently maintained weight gain above 20g/h/d over the previous two weeks. All lambs are sold if they reach a target live weight of 55kg (Cwt 25kg) at any time and all lambs are sold by the end of April regardless of the live weight attained.

Farm Systems Tested

<u>Base</u>

The baseline farm system (BASE) sells lambs as stores on a fixed date at the end of December. For the period from January to mid-March the ewe flock grazes all the paddocks of each pasture type in a time based rotation. From mid-march to lambing the flock grazes only the native pastures with the improved pastures spelled in preparation for lambing. During the period from lambing to the end of December all paddocks are available and grazing management is flexible with stock movement based on achieving the highest possible livestock performance.

<u>Finishing on existing pastures</u>

The first finishing system finishes lambs on pasture (PAST) and utilises the PHL and H-NAT pastures in a flexible rotation in order to maximize the final weight of the lambs. Lambs are weaned on the 1st of December and during the period from weaning until the end of April the PHL pasture is reserved for the sole use of lambs in a flexible rotation where the H-NAT pasture is also available to graze if seasonal conditions are such that the weight gain of the lambs would be better on this pasture type. The dry breeding ewes are run exclusively on the H-NAT and L-NAT pastures in a fixed rotation appropriate to the long term carrying capacity of these two pasture types.

<u>Finishing on Lucerne Pastures</u>

The second finishing system (LUC) tests the impact of grazing Lucerne on lamb performance. To characterize this system a Lucerne block with a 5 paddock rotation was simulated using a tactical simulation method. The starting pasture and soil water parameters were determined by first running a historical simulation and extracting the 20th, 50th and 80th percentiles for plant available water, phenology, shoot mass and root mass for the 1st of September (the starting date for the Tactical Simulation). Lambs entry weights for the LUC simulation are the 80th, 50th and 20th percentile taken from the BASE simulation on the 1st of December. Lambs enter the LUC system immediately after weaning on the 1st of December and are retained or sold based on the same sale rules as described for finishing on the existing pastures. The LUC finishing system was run at a range of stocking rates to determine the optimal stocking rate for the Lucerne pasture type when used solely as a finishing pasture. Once the likely optimal stocking rate was discovered the optimal proportion of Lucerne on the base 1000ha farm was solved using a simultaneous equation.

To confirm the optimal area of Lucerne and calculate the overall profitability of the farm system the BASE pasture mixed was substituted for Lucerne areas ranging from 125 to 225ha in size.

<u>Finishing on forage brassica</u>

The third finishing option tested used forage brassica (BRA) grazed by weaned lambs from December to April. As forage brassica is not parameterised for GrassGro its use was simulated within GrassGro as a production supplement fed in a feedlot such that the only source of nutrition or the lambs was a supplement of a feeding value equal to the average selected diet expected from grazing a forage rape crop.

Crop dry matter production was modelled outside GrassGro according to a published yield model for forage brassicas (Adams et al Agronomy NZ. **35**, 2005) that uses a degree day accumulation from a 4°C base to predict total dry matter yield.

$$Y \ = (11.1 \ x \ Degree \ Days \ - \ 3844.7) x \ \ GL(sw)$$

Since temperature was the major determinant of the growth model used, only data from the period 1995 to 2015 was modelled due to strong evidence that the climate has warmed since 1960 and the more recent years are more likely to be a better indicator of likely temperatures in future years. The predicted yield from this model was then scaled according to soil moisture conditions by applying the average soil water growth limit (GLsw) during the crop growth period from a GrassGro Lucerne tactical simulation over the same range of years and starting with soil at field capacity at the planting date of the 20^{th} of Sept. Two growth periods were modelled to determine the biomass available at the initial grazing and then the regrowth available for a second grazing after 6 weeks rest.

Scenarios were modelled for the 20^{th}, 50^{th} and 80^{th} percentiles for biomass produced /ha and areas available varied from 50 ha to 125 ha. Within GrassGro the forage brassica was offered to the lambs in a feedlot at a rate in accordance with the average allowance expected (Table 1) which was determined by extrapolation from the data of Judson (NSW Grasslands 25, 2010). Quality of feed consumed was based on Judson et al (NZ Grassland Assn. 75, 2013) and varied according to the utilisation rate.

Table 1. Characteristics of crop utilisation and the associated intake of dry matter used as inputs to the GrassGro production feeding rules.

Nominal Utilisation %	Grazing Allowance kg/h/d	Diet M/D¥ Mj/kgDM	Expected# Lamb growth g/h/d	Predicted* DM Intake (kg/h/d)
80	1.5kg	11.2	178	1.04kg
70	1.9kg	11.3	225	1.22kg
60	2.3kg	11.5	264	1.33kg

*Predicted from GrazFeed based on the diet quality and expected growth rate.
#Derived from data published by Judson (2010)
¥Extrapolated from data of Judson et al (2013)

The grazing allowance was determined by interpolating between the data points of Judson (2010) where the utilisation rate was determined by the difference between pre-grazing biomass and post-grazing biomass in an intensively grazed rotation. The diet ME was determined by applying the utilisation rate to the feed quality data of Judson et al (2013) which presented separately the nutritive value of leaf and three cutting heights of the stem for the cultivar “Winfred”.

The biomass produced and the grazing allowance was used to calculate the number of grazing days available to the weaned lambs at the three utilisation rates by three production percentiles and 6 areas of crop. The optimal area of crop at each utilisation rate was defined as the area that generated the nearest to 120 mob grazing days for turn off of finished lambs around the end of March.

Once the optimal area of crop to achieve target utilisation was determined, actual lamb performance and the economics of the farm systems including forage brassicas were analysed using GrassGro. The BASE simulation was modified by displacing a proportional mix of BASE pastures with the appropriate crop area so reducing the pasture area available for breeding ewes. The impact of crop availability on lamb performance was simulated by feeding the lambs a production ration in a feedlot. The amount of ration fed is equivalent to the dry matter intake (DMI) shown for each utilisation rate and the diet quality (M/D) in accordance with that shown in table 1. For all simulations the supplement took the form of the “as fed” crop at 18% dry matter and 16% crude protein.

The cost per tonne of the brassica “supplement” was set so that the total expenditure on supplements in each model run was equivalent to the cost of establishing and managing the total area of brassica crop. Based on real farm data from MFS members the cost of brassica crop establishment and management was estimated to be $326/ha (M Shannon *pers comm*).

In principle poorer seasons reduce the amount of forage able to be consumed by the lambs and hence raised the unit cost of each kg of crop consumed. The range of gross margins produced for each of the brassica production percentiles were then aggregated to produce a box plot which estimates the span of the middle two thirds of whole farm gross margin performance.

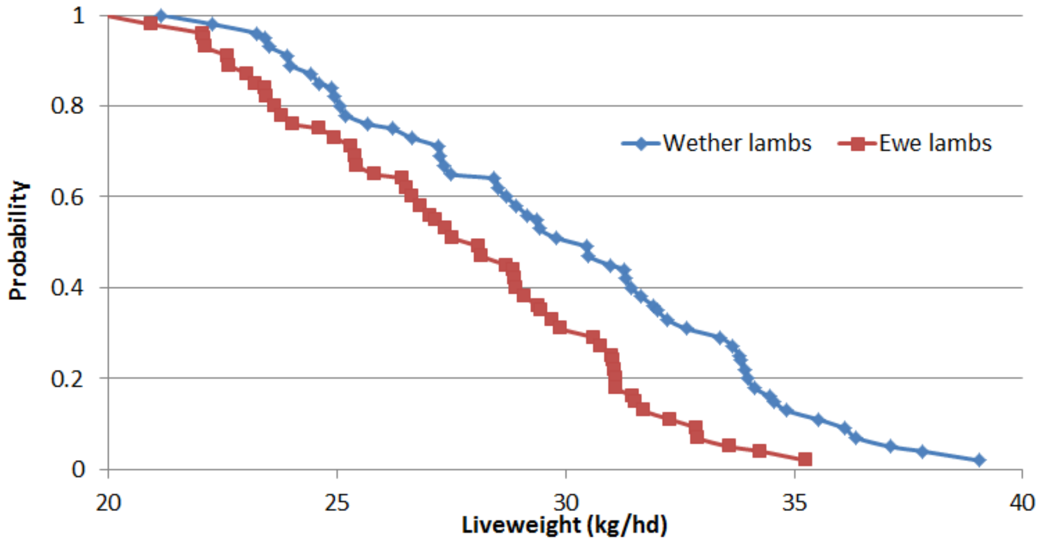
Results

BASE System

For the mix of improved and native pastures in the baseline simulation the optimal stocking rate was determined to be 3.4 ewes joined per hectare equivalent to long term annual rating of 5.1 dse/ha. At this stocking rate the long term pasture utilisation was 25%.

Lambs were all sold on a fixed date of the 31st of December and final sale weight depended on the pasture conditions prevailing each year of the run. Figure 1. shows the probability of the lamb sale weight exceeding any given level through the period 1960 to 2015. It can be seen that the lamb sale weight never fell below 20kg and at best reached 35 to 39 kg depending of the sex of the lamb. The median sale weight was 28kg for the ewe lambs and around 30kg for the wether lambs.

Figure 1. Probability density function for lamb sale weight from the BASE simulation.



Other parameters describing the physical performance of the BASE farm system are shown in Table 2.

Table 2. Long term average production summary for the BASE farm system

Total annual pasture yield (NPP) (sum)	kg/ha	5779
Dry sheep equivalents (av.)	dse/ha	5.1
Wool cut - total flock (sum)	kg CFW/ha	14
Wool cut - lambs (sum)	kg CFW/ha	0
Shorn fibre diameter - ewe adults (av.)	microns	18.8
Meat sold - total (sum)	kg LW/ha	123
Meat sold - young stock (sum)	kg LW/ha	93
Supplement fed/ewe	kg	52

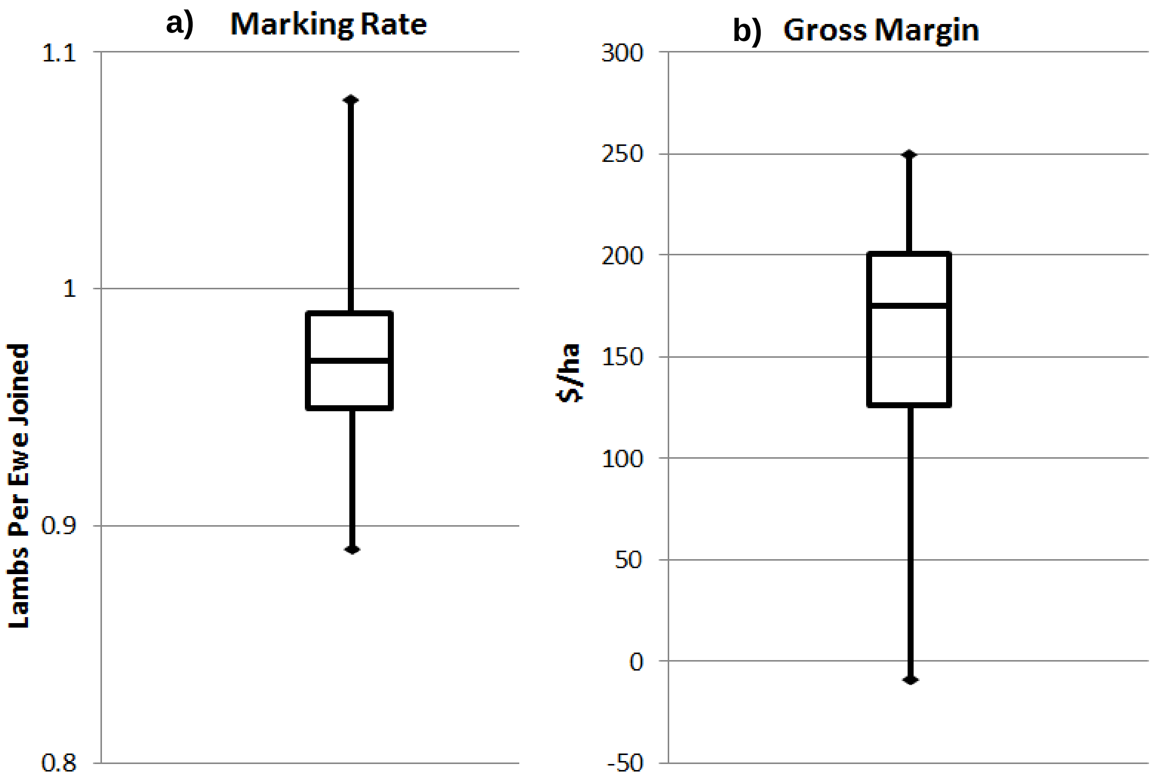
Lamb sales are a function of the stocking rate, the reproductive rate and the final sale weight. Figure 2a shows a boxplot of the marking rate of the BASE simulation. The average marking rate was 97% with a total range of 89% to 108% depending on the season.

Table 3. Long term average economic summary for the BASE farm system

Net wool income	$/ha	162
Sale income - young stock	$/ha	201
Sale income - cast-for-age	$/ha	45
TOTAL INCOME	$/ha	407
Maintenance supplement	$/ha	41
Shearing costs	$/ha	27
Animal husbandry	$/ha	28
Replacements purchased	$/ha	75
Rams purchased	$/ha	13
Sale costs	$/ha	22
Pasture costs	$/ha	42
TOTAL EXPENSES	$/ha	247
GROSS MARGIN	$/ha	161

Using the described cost and price structures these physical parameters translate into a long term average gross margin of $160/ha. Table 3. shows a breakdown of the long term average income and costs which go to determine the Gross Margin of the enterprise.

Figure 2. Range in marking rate and annual gross margin for the BASE system.



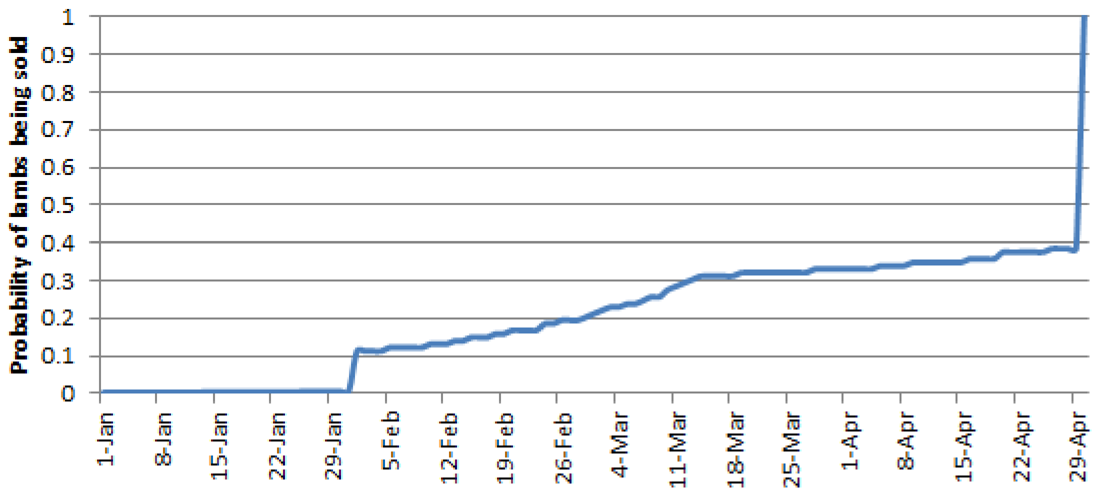
Of course there is considerable year to year variation in Gross Margin and Figure 2b shows a boxplot of the gross margins across the years modelled indicating a low of -$10/ha and a high of around$250/ha with the middle 50% of years in the range $125/ha to $200/ha.

Pasture (PAST) finishing system

With lambs retained into the new-year and potentially as late as the end of April the sustainable stocking rate was reduced only marginally to 3.3 ewes joined per hectare. The retention of lambs at this time of year did not unduly compromise the ground cover even though the total rating of the enterprise increased to 6.1 dse/ha. The lack of impact on ground cover can be explained by the flexible nature of the defined enterprise whereby lambs are only retained if pasture is sufficient to maintain a minimal weight gain. In years when pasture conditions deteriorate lambs are sold and ground cover protected. Under this finishing system at 3.3 ewes/ha the long term pasture utilisation was 30% representing a 20% improvement over the practice of selling all lambs as stores at the end of December.

The staged selling strategy described leads to the lamb sale date being somewhere between the start of February and the end of April. Figure 3 shows that summer pasture conditions were too poor to sustain lamb growth and were sold on the 1st of February one year in ten. Three years in ten lambs are sold by the middle of March but beyond this the slope of the line declines and lambs are retained through to the end of April six years in ten.

Figure 3. The probability that lambs will be sold by any given date



This broad range in selling date leads to an equally broad range in sale weight. Figure 4 shows that the minimum sale weight of wether lambs equals the median sale weight of the BASE simulation. Median sale weight has increased to around 40kg for wether lambs and 35kg for ewe lambs.

Additional production data is shown in Table 4 and of particular note is the increase in the total weight of young stock sold which has increased by 28% to 119kgLW/ha compared to the BASE scenario.

Figure 4. Probability of lamb sale weight from the PAST finishing system exceeding any given value.

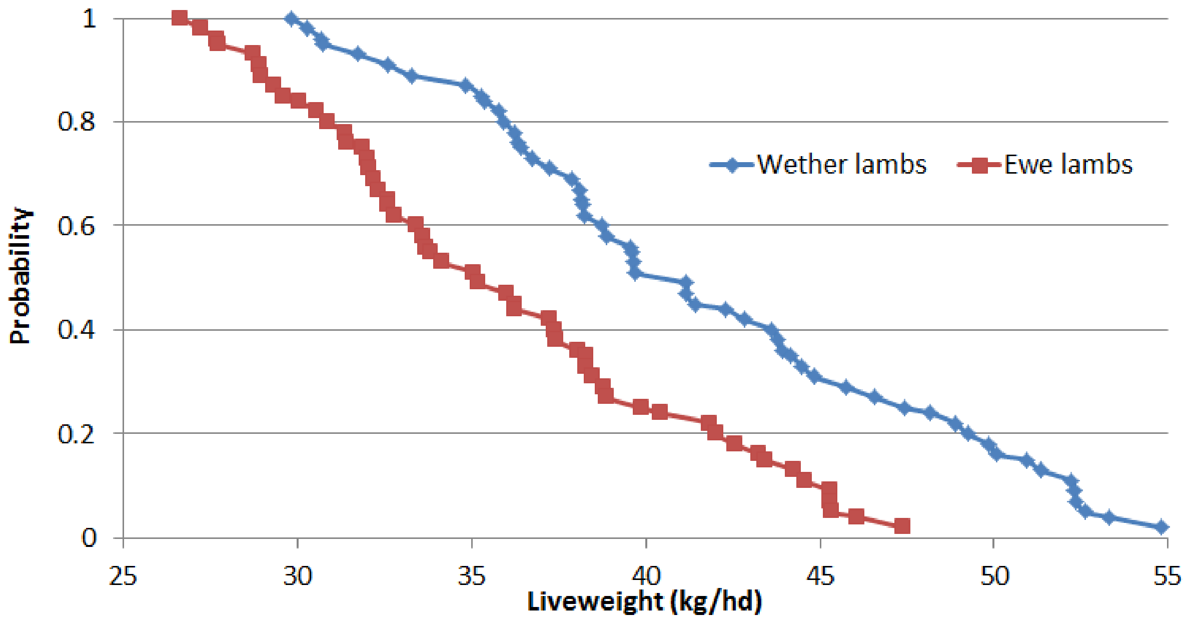


Table 4 Long Term Average Production Summary for the PAST Farm System

Total annual pasture yield (NPP)	kg/ha	5811
Dry sheep equivalents (av.)	dse/ha	6.1
Wool cut - total flock (sum)	kg CFW/ha	14
Shorn fibre diameter - ewe adults (av.)	microns	18.9
Meat sold - total (sum)	kg LW/ha	148
Meat sold - young stock (sum)	kg LW/ha	119
Supplement fed/ewe	Kg/hd	63

Under the same cost and price structures the PAST finishing system achieves a long term average Gross Margin of $236/ha more than 46% higher than the BASE system selling all lambs as stores at the end of December. Extra income is solely derived from the extra weight of lamb sold while there is a slight increase in the cost of supplements which is in proportion to the extra DSE being carried. (Table 5.)

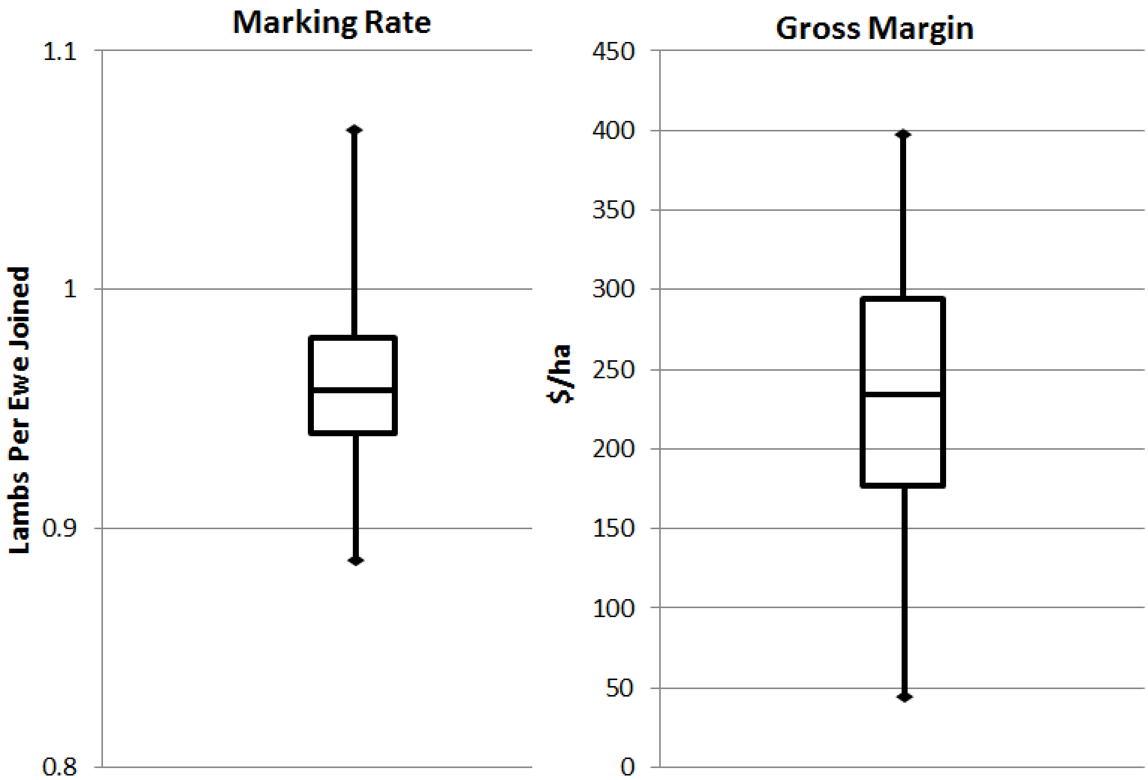
The increase in the number of sheep carried over the Summer – Autumn period has a detrimental effect on the condition of breeding ewes going into joining which carried through the breeding cycle. This impacts on the reproductive efficiency of the mob as seen in the boxplot in Figure 5a which is consistently 2% points lower that the base simulation. Finally in Figure 5b we can see the variability in Gross Margin (GM) across the simulation.

While the absolute variation in GM (around $350/ha) is greater than for the BASE simulation. Most importantly the minimum GM is about $60/ha higher than for the Base simulation and the median GM at $234/ha is well into the highest quartile of the BASE simulation so while the variability in GM for this finishing system is larger there is actually lower downside risk along with the reward of a much higher average.

Table 4. Long Term Average Economic Summary for the PAST Farm System

Net wool income - main flock	$/ha	159
Sale income - young stock	$/ha	287
Sale income - cast-for-age	$/ha	43
TOTAL INCOME	$/ha	488
Maintenance supplement	$/ha	47
Shearing costs	$/ha	26
Animal husbandry	$/ha	27
Replacements purchased	$/ha	72
Rams purchased	$/ha	12
Sale costs	$/ha	26
Pasture costs	$/ha	42
TOTAL EXPENSES	$/ha	252
GROSS MARGIN	$/ha	236

Figure 5. Range in marking rate and annual gross margin for the PAST system.



Lucerne (LUC) finishing system

Finishing lambs on Lucerne was initially analysed using a tactical simulation assuming that the Lucerne will be used solely for the purposes of lamb finishing. Even though the lambs were not weaned onto the Lucerne until 1st December the starting day of the simulation is the 1st of September. Having a three month "spin up" time means that the starting parameters for biomass, phenology and soil water have much less bearing on the simulation results. To set the starting parameters for the tactical simulation a single Lucerne paddock was added to the PAST historical run and the 20th, 50th and 80th percentile outputs for the 1st of September tabulated (Table 5)

Table5. Percentiles for important starting parameters on the 1st of September

Parameter	**Units**	**20%**	**50%**	**80%**
Phenology	Stage/°days	Veg / 359	Veg / 1628	Rep / 3365
Root Mass	kgDM/ha	218	399	735
Shoot Mass	kgDM/ha	207	434	839
Top Soil Water	m^3/m^3	24	26	29
Sub Soil Water	m^3/m^3	38	39	44

These starting parameters were tested to determine their effect on the simulation outcomes but they made little difference to the final outcome and to simplify the analysis the LUC tactical simulations were characterised with only the median level parameters. From these starting parameters the median annual production of Lucerne was 4400 kgDM/ha and production ranged from 990 kg DM/ha (1968) to 7500 kg DM/ha (1970).

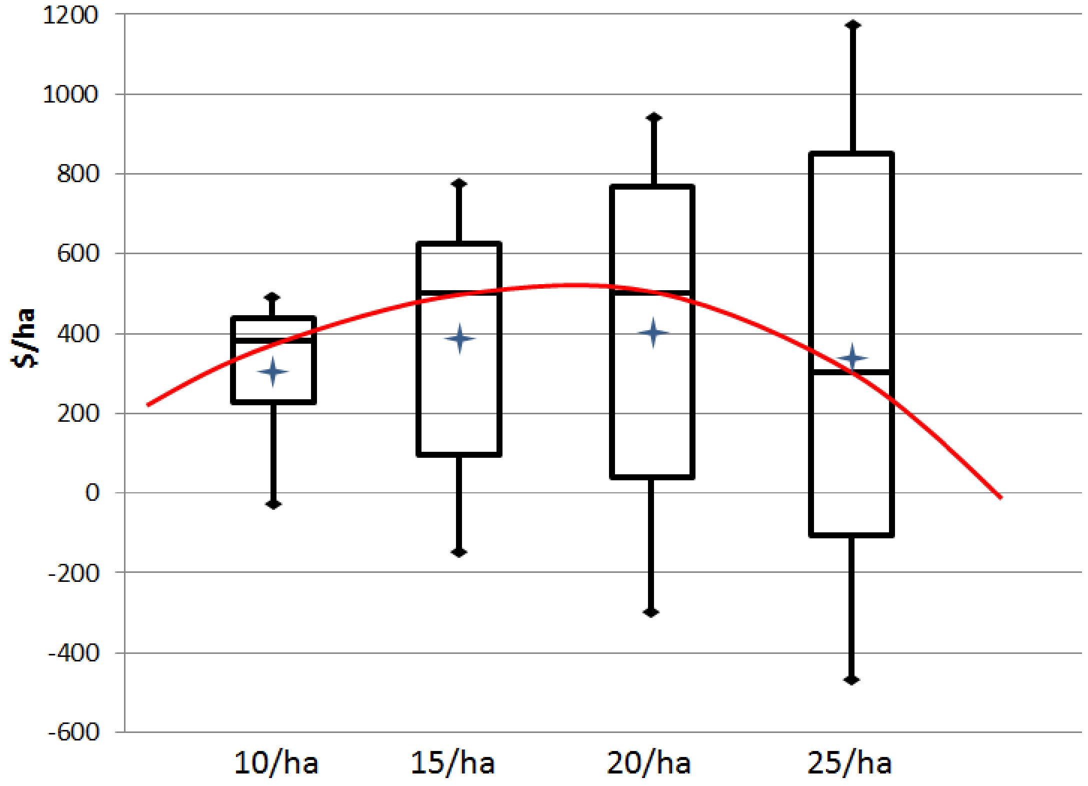
More critical to the ultimate outcome in terms of lamb sale weight and gross margin is the actual weaning weight used as the entry weight for the LUC system. In this case the BASE simulation was interrogated for the 20th, 50th and 80th percentiles for weaning weight (1st Dec) of both wether and ewe lambs (Table 6) and these weights used to characterize individual tactical simulations of lambs grazing Lucerne.

Table 6. Percentiles for weaning weight (lamb entry weight for LUC simulations)

Percentile	Wether Lamb Wt.	Ewe Lamb Wt.
20%	22	21
50%	26	24
80%	29	27

The optimal Stocking Rate of the LUC system was determined by running each of the lamb sex and entry weight combinations at each of 4 different stocking rates (10/ha, 15/ha, 20/ha and 25/ha) then aggregating the annual GMs for each stocking rate (6 x 56 year simulations = 336 annual GM's) to produce an overall boxplot of Gross Margins at each stocking rate. Figure 6. shows the distribution of gross margins expected at each of the tested stocking rates.

Figure 6. Effect of stocking rate (lambs/ha) on the GM of lambs finishing on Lucerne.



*Gross margins are calculated assuming an average weaned lamb value of $64 regardless of entry weight.
** Pasture maintenance for Lucerne set to $95/ha including $75/ha for fertiliser and $20/ha weed management costs.

The average gross margin (stars) for the lamb finishing component of the enterprise is highest at $402/ha at a stocking rate of 20 lambs/ha but when stocked at 15/ha is only $8/ha lower. Median gross margin (red line) is equal highest at $503/ha. On face value this makes the 15/ha stocking rate lower risk with the 5th percentile gross margin (lower whisker) being $150/ha higher than for the 20/ha stocking rate. Despite this the rate of 20/ha was chosen as the optimum stocking rate since the cost of establishment and the need to maintain the highest possible ewe number means it is desirable to use the minimum area necessary to economically finish the lambs. For this reason it is logical to run the highest practical stocking rate on the Lucerne so as to minimise the investment in new pasture while still getting the best possible economic outcome.

At 20/ha the total lamb weight gain is not maximised instead the most efficient use of the land resource is made. Table 7 shows the average turn off weight of wether lambs from the LUC system across the 4 stocking rates tested. Clearly the average lamb turn off weight per head is maximised at 10/ha but we know we know that the economic return from running twice that stocking rate is 40% higher.

Table 7. Lamb average turn off weight at 4 stock densities exclusively grazing Lucerne from December to April inclusive.

Stocking rate		10/ha	15/ha	20/ha	25/ha
Stock sale weight	kg	49	46	42	41

When stocked at 20 lambs/ha the average dry matter digestibility (DMD) of the Lucerne consumed by the lambs was 72% but ranged up to 76% in the better years. At 10/ha the higher sale weight reflects a slightly higher herbage diet quality averaging 73% but more importantly an ability to retain stock through dry spells without triggering the selling rules.

Integration of Lucerne in the LUC Farm System.

Lucerne in practice, while perennial, is seldom a permanent pasture and requires re-sowing at various intervals depending on variety and grazing management. If we assume that the life of an average stand on the Monaro is 10 years and a new paddock is largely out of production for 18 months in the pre-sowing and establishment phase then for each ha of Lucerne grazed there is another 0.15ha of land under preparation. Based on this proportion the effective stocking rate of the area allocated to Lucerne at any point in time is 17.4 lambs/ha.

Clearly the redevelopment of pasture to Lucerne dedicated to lamb finishing compromises the ewe numbers able to be carried. If the target stocking rate is 17.4/ha on the Lucerne and 3.8 ewes/ha is the sustainable carrying capacity of the BASE system when lambs are removed on the 1st of December then the actual area of land required to be allocated to Lucerne can be solved using the simultaneous equation shown below based on the following assumptions.

Farm Area = 1000ha

BASE area = Ba

Lucerne area = La

Lucerne Stocking Rate = 17.4

BASE Stocking Rate = 3.8 *(If lambs are removed from the system on 1st Dec)*

Average Weaning Rate = 0.97

Equation 1 La = 1000 – Ba

Equation 2 $17.4xLa = (3.8x0.97)xBa$

$\therefore \quad 17.4xLa = 3.7xBa$

Solving for Ba

$$17.4x(1000 - Ba) = 3.7xBa$$

$$17{,}400 - 17.4xBa = 3.69xBa$$

$$17{,}400 = 3.7xBa + 17.4xBa$$

$$17{,}400 = 21.1xBa$$

$$Ba = \frac{17{,}400}{21.1}$$

$$Ba = 825ha$$

$$\therefore \quad La = 175ha$$

Based on the simulated optimal Lucerne stocking rate a BASE farm of 1000ha would require 175ha of the farm to be allocated to Lucerne growing for finishing the weaner lambs from ewes grazing the remaining 825ha of BASE pasture

At an average weaning rate of 97% this means the average number of lambs for sale from the LUC system is 2980 at an average weight of 42kg LWt and 125kg of lamb turn off per ha compared with the BASE system selling around 3300 store lambs a year at the end of December at 28.5kg LWt for an average turn off of 93kg of lamb per ha.

Full system analysis

To confirm the optimised proportion of Lucerne in the system and to include the potential grazing value of Lucerne for breeding stock after lambs are sold, GrassGro systems with a proportion of Lucerne along with the same mix of native and improved pastures as the BASE system were simulated. 5 Lucerne paddocks and a fallow paddock (ungrazed) 15% of the size of the total Lucerne area were added to the system with the existing paddocks down sized to keep the total farm area at 1000ha. The total area of Lucerne / Fallow was varied which corresponded to the approximate stocking densities shown in Table 8.

Table 8. Nominal area sown to Lucerne and effective stocking rates allowing for 13% of the area fallowed for re-sowing.

Area of Lucerne/Fallow (ha)		125	150	175	200	225
Stocking Rate (lambs/ha)		30	25	20	17	15

In the LUC farm system weaned lambs had exclusive access to the Lucerne between weaning on the 1st of December and the last possible sale date of the 30th of April. If required the lambs also accessed the improved pasture and fertilised native pasture but only if their weight change was assessed to be better than if they remained on the Lucerne. At the optimal area of Lucerne the weaned lambs spend only 9% of the time on PHL pastures and no time grazing the H-NAT pasture. Despite this lambs spent some time on the PHL pasture in 23 of the 57 years simulated showing that this strategy allows the system to retain lambs longer during dry spells when the Lucerne is depleted allowing them to be retained without feeding for maintenance.

Increasing the area of Lucerne available increases the gross margin and reduces the total variability of the gross margin up to an area of 175ha (Figure 7) beyond 175ha the gross margin decreases only slightly as do the extremes confirming the most profitable area of Lucerne will be 175ha or less. At 175ha of Lucerne the long term average whole farm gross margin is $266/ha compared to just $244/ha at an area of 150ha. Compared to the economic output from the PAST finishing system (figure 5) this represents an increase in whole farm gross margin of $29,950 and $8,630 respectively. If this increase is attributed solely to the area of Lucerne sown then 175 ha of Lucerne achieves a gross margin of $407/ha while a sown area of 150ha achieves only $293/ha. What seems like a disproportionate change in farm profitability for the relatively small extra area is due to the core assumption that all lambs will be retained for finishing at a higher stocking rate than can be sustained. In practice with lesser areas of Lucerne only the number of lambs that could be successfully finished would be retained and the balance sold as stores much earlier.

The actual profitability of the investment in Lucerne is not truly reflected in the steady state gross margin of $407/ha, rather the establishment cost must be amortised by this gain in gross margin. NSW DPI budgets in 2011(the most current available) put the cost of Dryland Lucerne establishment at $271.94/ha including machinery and labour costs. Allowing for an average CPI of 2.5% over the period since 2011 an indicative cost in 2016 dollars would be around $308/ha.

The gross margin of 175ha of Lucerne and the cost of establishment were tested in the Pasture Cash Flow Calculator (NSW DPI 2012) to determine the cumulative cash flow attributable to the conversion of land from the baseline mix of phalaris and native pastures to Lucerne. The average scenario was tested where the average GM for the Lucerne was set to

$407/ha and compared to the PAST finishing system average GM of $236/ha. In addition the top and bottom quartile GM's for each system were compared.

Figure 7. Effect of area sown to Lucerne on the whole farm gross margin.

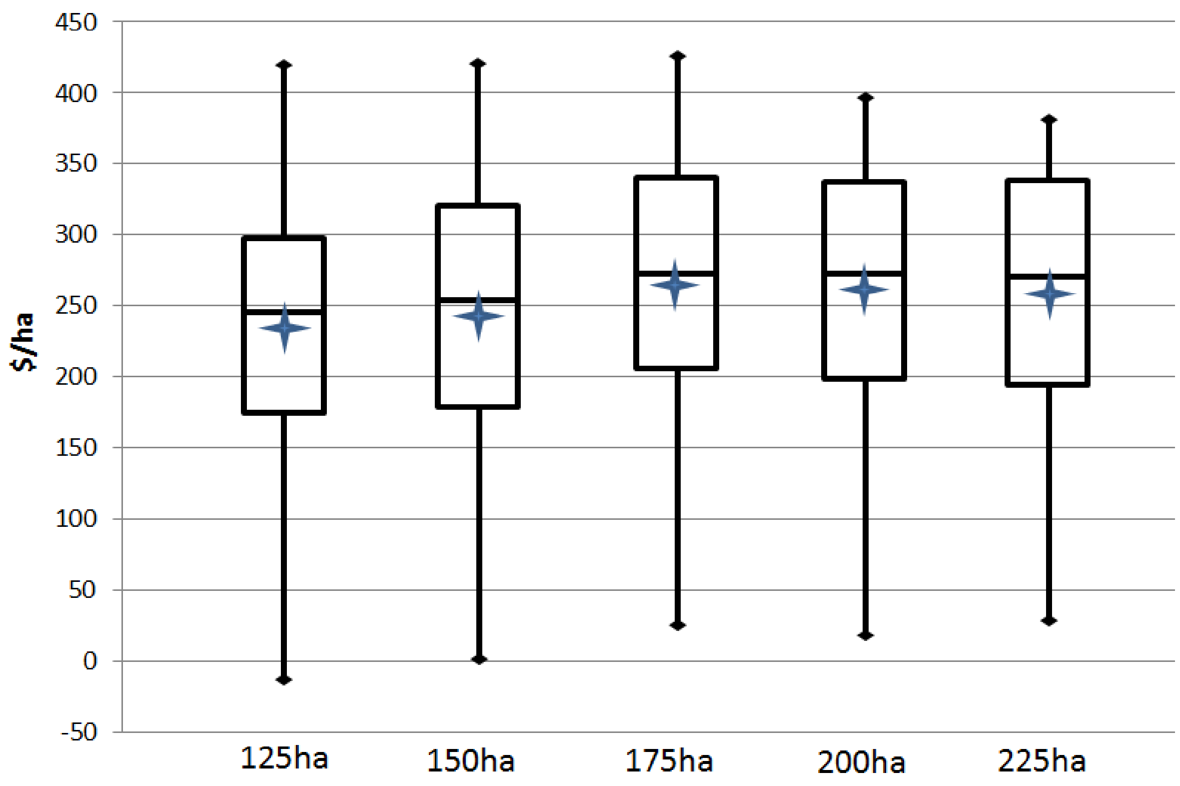
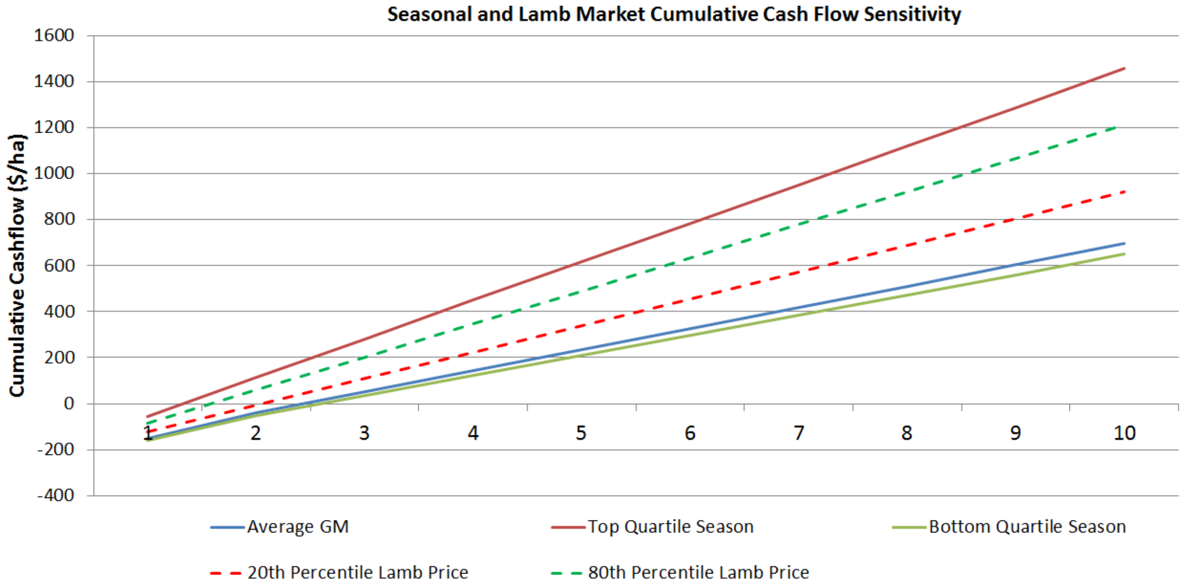


Figure 8 shows that the addition of Lucerne to the system is clearly profitable for any of these scenarios. Using average GM's the breakeven year is the 2nd full year of production. The bottom quartile scenario actually leads to break even in the same year and very similar cumulative cash flow which is attributable to the LUC finishing system having inherently lower downside risk and higher GM/ha than the PAST finishing system even in the poorer years. The top quartile scenario however has the potential to break even in the first full year of production and generate more than twice the extra cash flow in while ever good seasons prevail.

The impact of lamb price variation was also tested by applying 20th and 80th percentile lamb prices for the 5 years to June 2016 to the historical analysis to calculate the relative cumulative cash-flow generated by a run of average seasons. It is most interesting to note that for both the altered price scenarios the result was better than for the median price. Since the results are presented as cumulative cash flow relative to the PAST finishing system even though the absolute profit under poor lamb market conditions would be lower the difference in favour of Lucerne finishing is actually larger demonstrating the investment in Lucerne for lamb finishing is very robust to variations in both market and season.

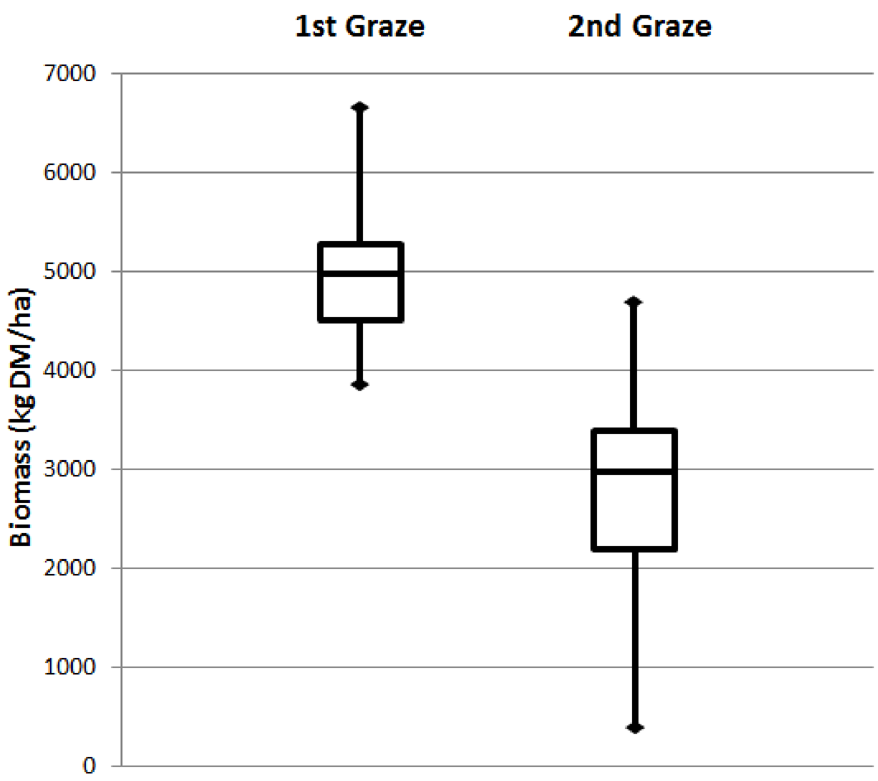
Figure 8. Cumulative cash flow of Lucerne compared to the base pasture mix.



Brassica (BRA) finishing system

As forage brassicas are not parameterised for GrassGro the biomass productivity had to be modelled using a different approach. As described in the methods a simple model using degree day accumulation attenuated with a soil moisture scalar was chosen to estimate the total biomass production of forage brassicas in the Bungarby climate.

Figure 9. Estimated range in biomass at the first and second grazing of forage brassica (cv Winfred) at Bungarby



Degree days are based on average daily temperatures between 20th Sept and 20th Dec 1995 - 2015 for the first grazing and 15th Jan and 28th Feb for the second grazing. The biomass at the second grazing was more variable due to the greater probability of dry conditions and reliance on in crop rainfall rather than stored soil moisture.

Biomass estimates from the two growth periods in each year from 1995 to 2015 were aggregated to generate total biomass production to inform the analysis of carrying capacity and lamb finishing capability. Judson (2010) and Judson et al (2013) published data that relates the relative grazing pressure and apparent utilisation rate with both animals and post grazing crop performance. This analysis calls on these published relationships as assumptions upon which to base the performance of lambs on spring sown brassicas on the Monaro.

Table 9 shows the expected utilisation rate at particular per head daily allowances of crop and the expected lamb growth rate at these levels of allowance. In each case the allowance is in excess of the actual intake which allows the animals to exhibit selectivity in their diet. This selectivity along with easier access to crop dry matter generates higher growth rates and demonstrates the trade-off between crop utilisation and per head performance. Crop percentiles (20%, median and 80%) have been modelled within each nominal utilisation rate.

The number of grazing days available to the lambs has been calculated from the crop allowance and the number of lambs able to be weaned of the remaining farm area. An area shaded red, indicates an area of crop which would be insufficient to last the mob the desired time, or allows insufficient time to allow regrowth for a second grazing. Areas shaded green indicate a crop area that would require more than the 150 days available to the end of April to consume it efficiently at the desired utilisation rate in a median season.

Total weight gain is calculated from the expected weight gain multiplied by the number of mob grazing days available at the desired utilisation rate. Orange shading indicate total weight gains that correspond to the combinations excluded on the basis of insufficient grazing days available. Purple shading indicates the weight gains that would be achieved for combinations for which there is insufficient time before sale to graze them efficiently

Table 9. Indicative utilisation rates at a range of daily feed allowances and calculated grazing days available and corresponding total post weaning live weight gain.

			DMI	Crop %_iles *	Mob Grazing Days				Total Lwt Gain (kg/hd)			
			Kg/h/d	kgDM/ha	50ha	75ha	100ha	125ha	50ha	75ha	100ha	125ha
Utilisation	80	%		6600	63	97	133	170	11	17	24	30
Allowance	1.5	kg/h/d	1.04	**7935**	76	116	159	205	13	21	28	37
Wt Gain	178	g/h/d		8745	83	128	176	226	15	23	31	40
Utilisation	70	%		6600	49	76	104	134	11	17	23	30
Allowance	1.9	kg/h/d	1.22	**7935**	59	91	125	161	13	21	28	36
Wt Gain	226	g/h/d		8745	65	101	138	177	15	23	31	40
Utilisation	60	%		6600	40	62	85	109	11	16	23	29
Allowance	2.3	kg/h/d	1.33	**7935**	48	75	102	132	13	20	27	35
Wt Gain	264	g/h/d		8745	53	82	113	145	14	22	30	38

*crop percentiles used are 20%, median and 80%

The unshaded combinations of utilisation rate and area and total crop production were characterised in GrassGro by displacing a proportional mix of BASE pastures with the shown crop area to reduce the area available for breeding ewes. The impact of crop availability on lamb performance is simulated by feeding the lambs a production ration in a feedlot. The amount of the ration is equivalent to the dry matter intake (DMI) shown for each utilisation rate and the ME in accordance with that shown in table 1.

Figure 10 shows the expected distribution of lamb sale weight for the three level of utilisation modelled in GrassGro. The distribution for each utilisation rate aggregates the results from the three brassica biomass percentiles (20%, median and 80%). The distribution in sale weight is partial influenced by the brassica production percentile but it is also impacted by the weight of weaners being produced from the associated ewes breeding flock. Unfortunately this approach cannot capture the full range of possible outputs as worst case and best case brassica production was not modelled.

Overall the distribution probably represents the middle 70% of possible sale weight outcomes. What the results clearly show is the impact on per head performance of running lambs at lower stocking rates and utilising a lower proportion of the crop biomass. To determine the optimum position in the trade-off between the crop area sown and the animal performance the physical outputs of the system were used to generate the associated distribution of gross margins.

Figure 10. Impact of crop area and hence utilisation rate on lamb sale weight.

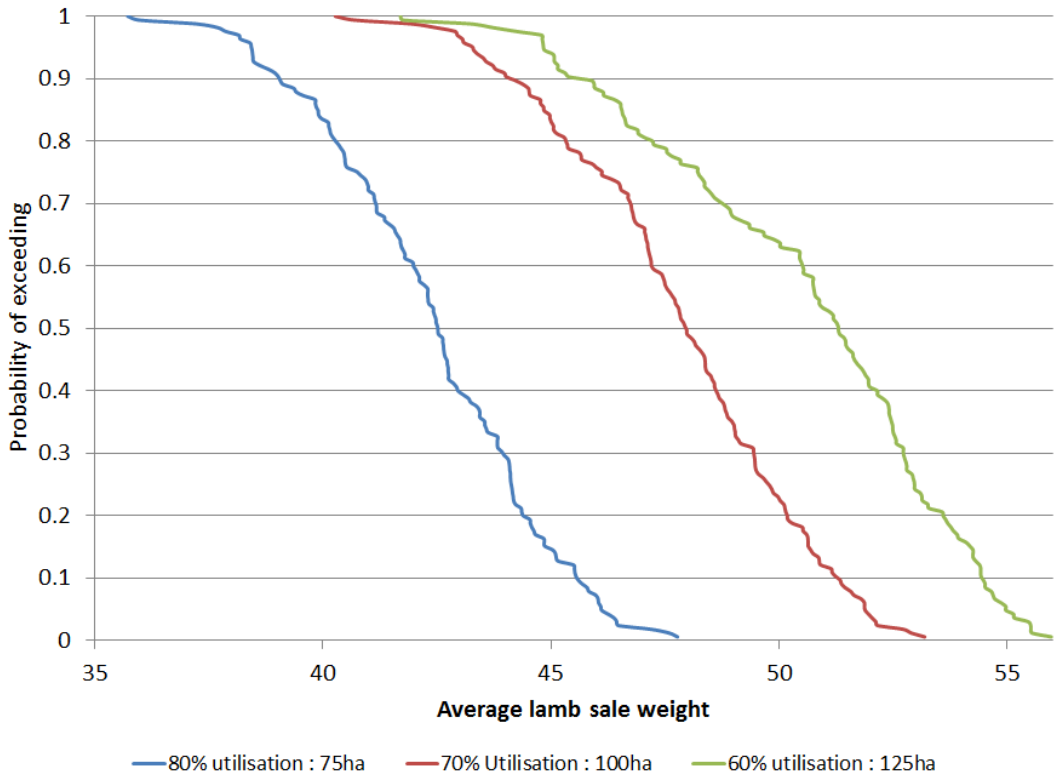
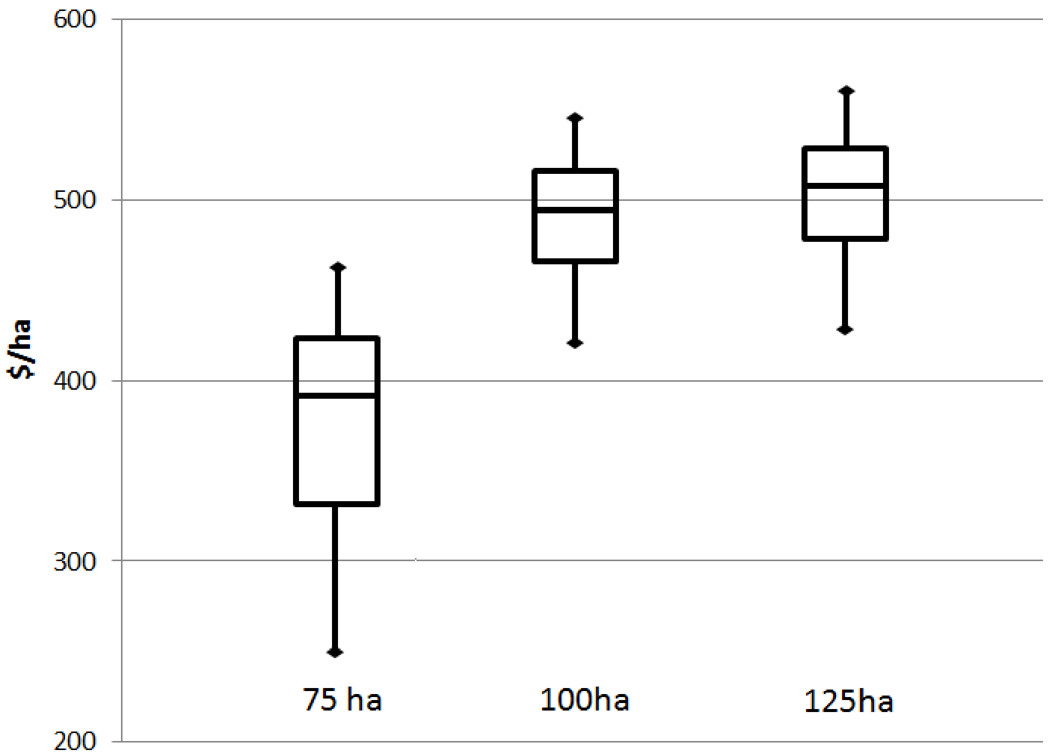


Figure 11. Impact on whole farm gross margin resulting from sowing a range of areas of brassica crop to finish all lambs before the end of April.



The annual gross margins determined for each crop growth percentile were also aggregated within utilisation / crop area treatments to illustrate the overall distribution of whole farm gross margin that could be expected from the sowing of different areas of crop for grazing by the entire cohort of lambs each year.

Figure 11 shows that despite the extra cost of establishment, sowing 100ha of brassica crop (10% of farm area) massively outperforms the sowing of just 75ha of crop. The reason for this is that the utilisation rate of 75ha is too high to gain best growth rates in the lambs when all lambs are retained to be finished (as evidenced by the expected growth rates and intakes in table 1). By the same token there is little to be gained by increasing the area of crop to 125ha as the value of the increment in lamb growth rate only just exceeds the cost of the extra crop. It should be noted however that the model does not account for any grazing value to the ewe flock should seasonal conditions allow a third grazing after the end of April.

Clearly despite being an annual cost the expenditure on brassica crop pays off and on face value has the potential to double the average gross margin of the farm compared to the PAST finishing system. This is largely due to the high productivity of the crop and hence it's relatively low cost per kg of DM consumed.

Discussion

Given the current pricing structures in industry the current trade of between ewe numbers vs retaining lambs to finish is unquestionably in favour of retaining lams to finish. Compared to selling all lambs as stores the opportunistic practice of retaining lambs on farm up to the end of April lead to an improvement in gross margin of $75/ha and due to the flexible selling strategy used there is little trade of in terms of ewe stocking rate or increased economic risk to the system. Overall the strategy increases the utilisation rate of the existing pastures and increases the calculated dry sheep equivalent being run both factors that are understood to be drivers of economic performance of enterprises.

When Lucerne is substituted for pasture in the farm system the whole farm gross margin rose substantially and steadily up to a maximum at 175ha of Lucerne. Once Lucerne area is optimised the average whole farm gross margin is $30/ha higher than for the pasture based finishing system. If the increase in whole farm gross margin is attributed to solely to the Lucerne area sown then the improvement in gross margin is substantially higher at $177/ha. It should also be noted that this financial performance is predicated on a dry matter production averaging just 4,400 kgDM/ha which local experience would suggest is a conservative estimate of the productive capacity of Lucerne in the Bungarby environment.

What is clear from the analysis is that these profits are predicated on the Lucerne area being stocked at its appropriate capacity. While 175ha of land dedicated to Lucerne is needed to finish all lambs being produced on the 1000 ha farm (17.5% of farm area) if the area of Lucerne is less than this the profitability per ha sown should remain at similar levels as long as the stocking rate is held to around 20 lambs per ha by selling down a proportion of the lambs as stores.

While the analysis of the use of brassica crops certainly appears to be the most profitable option for the finishing of prime lambs it should be noted that the production parameters are predicated on research from outside of the Monaro and are modelled in a simplistic way. Based on the research of Judson and others, targeting an appropriate utilisation rate is critical to maximizing the economic performance of forage brassicas. As with the Lucerne modelling if the appropriate area of crop to finish the entire drop of lambs is not available then early selling of the surplus portion of the lamb drop will be a more profitably strategy than over utilising the crop and suppressing per head performance. By substituting forage brassica for pasture it appears that around 10% of the farm area should be sown to crop if the entire lamb drop is to be finished in the most profitable way. The difference in whole farm gross margin is stark when this is achieved with an increase in average GM of over $230/ha. Unfortunately being an annual crop most appropriately grown in a rotation it is probably impractical to allocate 10% of the farm area to fodder brassicas each year.

The increases in profit shown for each of the systems tested is based on the fact that the only enterprise being run on the farm is a ewe breeding flock where all progeny are by terminal sires and destined for sale as lambs. Clearly on farms where there are a mix of enterprises including merino self-replacing flocks and cattle the number of lambs requiring finishing will be less making the allocation of the best pastures to the prime lambs and easier proposition. In this case the best strategy for specialist systems such as Lucerne and forage brassicas would be to grow sufficient area to handle the number of lambs to be finished. On Lucerne this approximates 5 ha per 100 lambs to be finished. On forage brassicas an allocation of crop DM of around 2kg/lamb/day would be appropriate. Based on a total crop dry matter production of 8 tonnes between sowing and 1st of April around 3ha of crop would be required per 100 lambs to be finished. Clearly capacity will vary according to season and for both Lucerne and forage brassicas some field work to validate the modelled production levels would be desirable.

Conclusion

In most cases the required area to enable finishing of entire cohorts of lambs is larger than practical in the Monaro landscape if the sole enterprise is geared around prime lambs. In practice where prime lambs are only one of the enterprises on the farm then the amount of Lucerne or Brassica crop required will only be in proportion to the land area being used to run the prime lamb enterprise. What is clear is that under the prevailing lamb price and cost structures, based on the modelling presented good profits can be made from increasing the proportion of the land area allocated to the enterprise to 17.5% for Lucerne or 10% for brassicas. If less than that proportion of the land area is able to be developed then to maximise profits the number of lambs retained to finish should be proportional to the actual area of Lucerne or brassica available.

MFS members who are experienced users of forage brassica crops were consulted for their reaction to the modelling work presented and in general while broadly in agreement with the conclusions it is likely the modelled herbage production for the brassicas is an over estimate while and an underestimate for the Lucerne. In this light some Monaro specific monitoring of both Lucerne and regrowth brassicas would be desirable to help adjust the growth models and fine tune the conclusions of this work so as to give producers greater confidence in the results.

Appendix 1. Base Simulation Inputs

Farm

1000ha with the following paddock structure.

Pasture Type	No of Paddocks	Paddock Size (ha)
Phalaris Improved	5	50
Native Fertilised	5	70
Native	4	100

Pastures

Pasture Type	Pasture Species			
Phalaris Improved	Phalaris	Tall Fescue	Annual Grass	Sub Clover
Native Fertilised	Poa Tussock	Corkscrew	Sub Clover	Medic
Native	Poa Tussock	Corkscrew	Sub Clover	Medic

Soil

Stony Basalt	Topsoil	Subsoil
Cumulative depth (mm)	300	1000
Field capacity (m^3/m^3)	0.35	0.45
Wilting point (m^3/m^3)	0.22	0.37
Bulk density (Mg/m^3)	1.16	1.20

Livestock

Livestock Genotype		
Breed	Medium Merino	
Standard reference weight	45.0	kg
Greasy fleece weight	5.6	kg
Fibre diameter	18.6	kg
Fleece yield	71	microns
Ram breed	Poll Dorset (Mature ram: 90.0 kg)	
Death rate: adults	4.0	%/year
Death rate: weaners	4.0	%/year

Livestock Management

Stocking rate	3.4/ha	
Shearing date	1 Apr	
Replacement rule	**Purchase**	Purchase ewes on 1 Feb at age 17 months, live weight 45 kg and C.S. 3.0
	Cast for age	Sell stock aged 6 to 7 years on 15 Jan

First join at	1 years
Mating date	15 Mar
Conception at CS 3	(1) 55% (2) 40% (3) 0%

Birth date	11 Aug
Castration	yes
Weaning date	30 Dec
One ram per	80 ewes
Keep rams for	3.0 years

Maintenance Feeding rule

Mature Females	Feed in paddock, applying the rule: If animal condition falls to 2.5 during 1 Jan to 31 Dec feed to maintain condition of average animals
Immature Females	Feed in paddock, applying the rule: If animal condition falls to 2.5 during 1 Jan to 31 Dec feed to maintain condition of average animals
Weaners	Feed in paddock, applying the rule: If animal condition falls to 2.0 during 1 Jan to 31 Dec feed to maintain condition of average animals
Supplement	

Ingredient	**Wheat, whole**
Dry matter content (%)	89
Dry matter digestibility (%)	84
ME:DM (MJ/kg)	13.0
Crude protein (%)	13

Costs: Monaro Median 2016

Description	Sheep Costs for 2016 70kg.ha single super + $10/ha weeds	
Ewe Shearing	$8.00	/head
Shearing Lambs	$8.00	/head
Ewe Husbandry	$3.00	/head
Lamb Husbandry	$5.40	/head
Ewe Replacement	$100.00	/head
Rams	$900.00	/head
Sheep sales commission	5.00	%
Sheep sales cost	$2.50	/head
Pasture cost	$42.00	/ha
Wheat, whole	$230.00	/t

Prices: Monaro Median 2016

Description	5 year prices July 2012 to June 2016		
Wool prices for ewes	17 micron	1529	c/kg
	18 micron	1385	c/kg
	20 micron	1221	c/kg
	21 micron	1079	c/kg
	Av. Fleece Price	90.0	%

	Wool commission	4.0	%
Ewe sales	Base price	299.0	c/kg
	Dressing percentage	42.0	%
	Skin price	$14.70	/head
Lamb sales	Base price	492.0	c/kg
	Dressing percentage	42.0	%
	Skin price	$6.80	/head
lamb price scaling	Month	Scale	
	Jan	0.97	
	Feb	1.03	
	Mar	1.09	
	Apr	1.06	
	May	1.03	
	Jun	1.06	
	Jul	1.04	
	Aug	1	
	Sep	0.99	
	Oct	0.96	
	Nov	0.93	
	Dec	0.95	